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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a Provisional Patent Application under 37 CFR 1.53(b)(2).

Inventor(s)

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Title

NITINOL ICE BLADES

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Papers enclosed in Application

- 13 pages of specification including 7 claims and an abstract
- 4 sheets of drawings with 10 figures
- A check in the amount of $80.00 for the filing fee. **Applicant claims status as a small entity.**
- A receipt postcard

This invention was not made by an agency of the U.S. Government or under any contract with an agency of the U.S. Government.

CERTIFICATE OF MAILING

I hereby certify that I am depositing this correspondence with the United States Postal Service as Express Mail, Receipt No. ET 579 423 109 US in an envelope addressed to Commissioner for Patents, Box Provisional Patent Application, Washington DC 20231 on the date written next to my signature, below.

J. Michael Neary — Feb. 21, 2002
J. Michael Neary — Date

Respectfully submitted,

J. Michael Neary, Reg. No. 25,453
Attorney for Applicant

ET 579423109 US

Nitinol Ice Blades

This invention pertains to ice blades made of Nitinol, and to processes for making Nitinol skate blades.

BACKGROUND OF THE INVENTION

Ice skating is a widely popular sport. The evolution of skating has led to many innovative changes in the hardware used in this sport. These innovations include improved designs for skate blades and the metals used for the blades. Two types of metal are most commonly used for skate blades: stainless steel and high-carbon steel. The most important consideration when selecting a skate blade material is the hardness of the metal surface that rides on the ice, which must be hard enough to minimize erosion of the blade but not so hard as to be brittle. Hockey blades, especially, must be malleable enough to absorb impacts without shattering.

Another important factor is the corrosion resistance of the blade. As a blade corrodes, the cutting edge deteriorates, thus becoming dull. When skate cutting edges are dull, they do not effectively cut into the ice. Sharp cutting edges are important, especially when a skater is making turns. Presently, it is not uncommon for hockey players to grind their skates twice during a competition game. All skating rinks have grinding equipment to provide for the regrinding of blades. Improvements in the ability of ice skate blades to retain a sharp edge and resist corrosion would be an important factor in the sports of hockey, speed skating and figure skating.

A third factor, not commonly considered for conventional skate blade design, is the coefficient of friction of the blade on the ice. Skate blades concentrate the weight of the skater in a small area and the resulting pressure produces a film of water, which lubricates the skate blade as it slides over the ice surface. However, there is solid ice contact on skate blade edges during skating, particularly during turning and hard edging while accelerating forward. Improvements to the coefficient of friction of the skate blade

on the ice would improve the speed and smooth feel of the skates and would be a an improvement much welcomed by skaters.

The same characteristics would also be useful for other ice sliding equipment such as sleds and ice boats, and on other sporting vehicles intended for use on ice, such a luge, bobsled and skeleton.

SUMMARY OF THE INVENTION

Accordingly, this invention provides a Nitinol skate blade and processes for manufacturing a Nitinol skate blade that provides capabilities unavailable in current blades or any known variant of current blades. The Nitinol skate blades of this invention run faster on the ice, turn better, and last longer between sharpenings than any skate blade ever known to man. Moreover, they are lighter and chatter less on the ice than current state-of-the-art skate blades. These Nitinol skate blades are corrosion resistant so they will not rust like steel blades between uses, and they have a lower Young's modulus and a higher damping capacity than steel, so they tend to hold their grip on the ice better than steel blades. They have a lower coefficient of friction on the ice than steel and they can be heat treated to have a very smooth and hard oxide finish that is even harder and smoother, and has a lower coefficient of friction to produce exceptional running properties on the ice.

The invention includes processes for manufacturing Nitinol skate blades. They are cut by abrasive water jet from rolled Type 60 Nitinol sheet and are heat treated to reduce brittleness and improve toughness and impact strength, and give the skate blade an elastic property which I call "ultraelasticity".

The part may be hot machined to reduce it to near net size, and may be ground to reduce the part to the exact specified part size. For example, cylindrical parts can be centerless ground; balls can be ground in a conventional ball grinder; flat stock can be surface ground. For parts requiring a smooth surface finish, polishing or lapping provides the specified surface finish on the part, down to 0.5 microinch RMS or finer. The part may be heat treated to obtain the desired hardness, from RC40 to RC65.

An integral surface oxide of any of several colors can be formed on the surface of the part. The oxide surface may itself be polished to an even finer surface finish. These

process elements may all be used to produce a particular part that requires the characteristics provided by each process element, and they may be used in combinations that omit particular process elements or substitute others to give the desired characteristics of the part.

Shape memory effect in Type 60 Nitinol, never before known to exist, may be obtained by heat treating to about 675°C - 700.C and then cooling slowly over 8-10 hours in the oven.

This invention is for the use of the Nitinol (Nickel-Titanium) metallic material for blades that run on ice In particular, the Nitinol material can be used as hockey, figure and speed skating blades. Although both the Type 55 and Type 60 Nitinol material can be used for blade fabrication, the preferred material is the Type 60. Type 60 can be processed to have high hardness (up to Rockwell 62C). has excellent toughness properties, a weight approximately 16% less than steel, superior corrosion resistance, and can be polished to have mirror finishes.

The unique physical characteristics of Nitinol make it the ideal material to be used for ice skate blades. The corrosion resistance of the material is truly remarkable and blades made from Nitinol will never rust when used on ice. Corrosion of existing steel and stainless steel is a major cost factor to the ice sport industry. Presently, the manufacturers of high carbon steel blades chrome plate the blades in an attempt to reduce the effect of corrosion. The problem this approach is that the runner (bottom) of the blades are constantly being ground, which of course removes the chrome plating. After exposure to the ice (water) the bottom of the blade corrodes (and thus dulls) rapidly. This corrosion process also occurs on stainless steel blades. However, this takes longer. Salt for corrosion tests performed on high-carbon steel showed signs of corrosion in salt water within eight minute, and four hours on 440C type stainless steel. The same tests performed on Nitinol showed no corrosion after several thousand hours of exposure to salt fog.

DESCRIPTION OF THE DRAWINGS

The invention and its many attendant benefits and advantages will become better understood upon reading the following detailed description of the preferred embodiments in conjunction with the following drawings, wherein:

Fig. 1 is an exploded elevation of a hockey ice skate having a Nitinol skate blade in accordance with this invention;

Fig. 2 is an exploded elevation of a hockey ice skate blade holder and skate blade exploded out of the holder;

Fig. 3 is a end view of the skate blade shown in Fig. 2;

Fig. 4 is an end elevation of the skate blade mounted in the holder shown in Fig. 2;

Fig. 5 is a is an elevation of a figure skate having a Nitinol skate blade in accordance with this invention;

Fig. 6 is a sectional elevation of the Nitinol skate blade shown in Fig. 5;

Fig. 7 is an end sectional elevation of one version of the skate blade shown in Fig. 5;

Fig. 8 is an end sectional elevation of another embodiment of the skate blade shown in Fig. 5;

Fig. 9 is an elevation of a speed skate blade in accordance with this invention; and

Fig. 10 is a sectional elevation of the skate blade shown in Fig. 9.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, wherein like reference numerals designate the same or corresponding parts, and more particularly to Fig. 1 thereof, a hocky skate 20 is shown having a boot 23 and a blade holder 26 in which a skate blade 30 in accordance with this invention is removably mounted.

As used herein, the term ice skate is intended to encompass other types of apparatus and equipment that slide on ice, such as sleds and ice boats, and sporting vehicles intended for use on ice, such a luge, bobsled and skeleton.

Nitinol is a nickel-titanium intermetallic compound invented at the Naval Ordinance Laboratory in the early 1960's. It is a material with useful properties, but manufacturers who have worked with it have had little success in making Nitinol parts and semi-finished

forms. Because Nitinol is so extremely difficult to form and machine, workers in the metal products arts usually abandoned the effort to make products out of anything except drawn wire because the time and costs involved did not warrant the paltry results they were able to obtain.

Nitinol, particularly Type 60 Nitinol (60% Nickel and 40% Titanium by weight), has many properties that are unrecognized as of potential value. It can be polished to an extremely smooth finish, less than 1 microinch rms. It is naturally hard and can be heat treated to a hardness on the order of 62Rc or higher. It can be processed to have a very hard integral ceramic surface that can itself be polished to an even smoother surface than the parent metal. It is non-magnetic, immune to corrosion from most common corrosive agents, and has high yield strength and toughness, even at elevated temperatures. It is 26% lower density than steel for weight sensitive applications such as aircraft, satellites and spacecraft. However, there has hitherto been little effort in making useful parts out to Nitinol because it is so difficult to work, because it was known to be brittle, and because there has been no known method to make parts and forms out of Type 60 Nitinol.

Nitinol ice skate blades have to be processed to have both toughness and hardness. The hardness (Rockwell C) and toughness (yield strength) of the blades is determined with the heat treatment process. The optimum hardness of the blade strong back is 48 to 53 Rockwell C. The hardness of the bottom of the runners can also be processed to have a higher hardness (up to 62 Rc) if desired.

Tests performed on 60 Nitinol Hockey blades showed substantially improved results. Hockey skaters stated the blades provided improved turning and much higher speeds on the ice. The testers also used the blades for extended periods of time and never had to re-sharpen them.

Another feature of the Nitinol ice skate blades is their appearance. Nitinol can be polished to have mirror finishes and can also be heat treated to produce different colors. Polishing of the blades also provides a finish with low friction, which also contributes to faster speeds on ice. The blades can also be processed to have a course (dull) finish. By sand blasting or shot peaning and then heat treating the blades they will have a black finish. This finish is an oxide and provides a hard and tough coating on the blades

surfaces, estimated to have a hardness of -70 Rockwell C. This oxide occurs over the blades entire external surface, including the bottom edge of the blade. With the oxide applied on the bottom edge, which runs on the ice, additional erosion resistance and lower coefficients of friction are obtained.

Another feature of Nitinol is its ability to be processed to have high toughness properties. By heating a blade in a furnace to between 600 and 800 degrees C, the blades have high hardness and toughness. The optimum hardness for the blades is 49 to 53 Rockwell C and a yield strength of over 120,000 psi. Using the above processes these properties can be obtained.

The surface of the blade that contacts the ice can be heat treated to have high hardness, up to 62 Rockwell C. The process consists of heat sinking the strong back of the knife and heating only the contact surface to approximately 900 to 1000 degrees C with an aceletyne torch or induction coil, and then rapidly quenching the knife in water or oil.

Grinding of the running surfaces of the skate blades is desirable. On some blades a hollow grind is used, for example hockey skate blades. On other types of blades a flat or wedge grind is preferred. Grinding and final forming of the blades may be performed on a conventional skate blade sharpening machine such as a "Blademaster" three station skate sharpening machine made by Guspro Inc. in Chatham, Ontario, Canada. Conventional skate blade grinding equipment, such as the Blademaster, uses silicon carbide blades and diamond hones for the final pass. For Nitinol skate blades in accordance with this invention, the process is similar but differs in significant aspects, noted below.

Type 60 Nitinol skate blades rarely, if ever, need sharpening. The ice-contact edge is so hard and abrasion resistant, especially if hardened and oxide coated, that there is very little abrasive wear of the edge material. Moreover, the material is essentially corrosion-proof, so there is no significant corrosion of the ice-contacting edges, which is the primary cause of edge dulling in conventional skate blades.

Polishing after the diamond hone pass will further improve the surface finish and even further reduce the coefficient of friction with the ice. Polishing is done using diamond paste on a buffing wheel. Diamond paste can also be used to polished the oxide

film, if it has been applied- Permanent marking of the blades, part numbers, logos, serial numbers etc, can be accomplished using electro-chemical etching or laser engraving processes. If chemical etching is to be used, the markings should be applied prior to the application of the oxide film because the oxide is an effective electrical current isolator and interferes with the electro-chemical etching process. Laser etching processes however, work well on both the uncoated and coated material.

Nitinol is a family of intermetallic materials containing nickel and titanium. Nitinol was invented at the U.S. Naval Ordnance Laboratory in White Oak, Maryland and was named to indicate its composition and origin of development: Nickel Titanium Naval Ordinance Laboratory. The best known Nitinol composition is Type 55 Nitinol, containing a nearly equal atomic mixture of nickel and titanium, which is about 55% by weight nickel and about 45% by weight titanium. Other elements, including iron, and copper are sometimes added to modify the material properties, such as transition temperature.

Another lesser known and understood intermetallic compound of Nitinol, Type 60 Nitinol, has a composition of about 60 weight % nickel and about 40 weight % titanium. This material has properties of hardness and strength that significantly exceed those of Type 55 Nitinol, but has not been accepted commercially because it was thought to be too difficult to work and machine, and was thought to have properties that made it undesirable as a structural material, namely, brittleness, notch sensitivity, and an unpredictable tendency to explode when cooling after heating and during forging.

The interesting properties of pseudoelasticity and shape memory have not been thought to exist in Type 60 Nitinol. Indeed, Type 60 Nitinol has been thought to have no significant elastic properties at all. It has been thought to be too brittle and notch-sensitive to serve as an engineering or structural material. However, I discovered that Type 60 Nitinol can be processed to a state at which it exhibits significant elasticity, which I have named "ultraelasticity" to distinguish it from "superelasticity" of Type 55 Nitinol. The metallurgical mechanisms that produce ultraelasticity are not fully understood at this time, but the elastic properties of Type 60 Nitinol, properly processed in accordance with this invention, are readily demonstrated in standard objective tests on sample coupons, and also in practical application of the material in applications previously possible only with superelastic Type 55 Nitinol.

The properties of ultraelastic Type 60 Nitinol are as follows:

Elastic range: up to about 6%-7% strain.

Temperature range in which ultraelasticity is exhibited: -150°C to at least about 600°C and maybe as high as 750°C.

Ultraelastic Type 60 Nitinol also has the following useful properties: hardness that is adjustable from about 22RC up to about 64RC, low density, high strength (at higher hardness heat treats), low modulus, takes a fine surface finish, low CTE, low thermal conductivity, corrosion resistant, and non-magnetic. At low hardness (22RC-35RC), it has very low yield strength (15KSI-55KSI) and little elasticity, that is, it can easily be plastically deformed with little springback, and is very malleable, that is, can be extensively deformed or strained without cracking.

The processes for producing ultraelasticity in a Type 60 Nitinol semi-finished form or workpiece is described in detail in my pending Patent Application No. 09/879,371 entitled "Manufacturing of Nitinol Parts and Forms", the disclosure of which is incorporated herein by reference. Briefly, it includes heating a workpiece in a heater, such as an oven or furnace or the like, to a working temperature of about 900°C-950°C. The workpiece is held at the working temperature for long enough for the heat to penetrate entirely to its core and for a soak period at that temperature. I have found that a heating period of at least one hour at that temperature is usually enough for plate of ½-¾" thick, lesser for a thinner plate. The heated plate workpiece is removed and subjected to hot working in a hot working apparatus by rolling to reduce its dimension toward the desired thickness and length. "Hot-working" is defined as straining the workpiece by about 20%, more or less, while holding it at the working temperature. Examples of hot-working include forging, rolling, hot extrusion, and machining.

The rolled plate 10 produced by this series of heating and rolling steps is very hard and brittle. To obtain the desired ultraelastic properties, the plate 10 is now returned to the oven 12 as shown in Fig. 3 and heated to about 600°C-800°C, preferably about 675°C ±10°C, and is held at that temperature for a post-hotwork heat soak period for 15-60 minutes or longer, for example, several hours. At the end of the post-hotwork heat

soak period, the workpiece is removed from the oven and is quenched to reduce its temperature quickly.

The ultraelastic Type 60 Nitinol workpiece may be heat treated to a desired combination of hardness and elasticity. For example a hardness of about 58RC-64RC may be obtained by heating it to about 900°C-950°C and then quenching in water or other coolant such as oil to cool it quickly to a temperature below about 500°C. The coolant should be agitated or the part moved in the coolant bath to ensure a flow of coolant over the surface of the part to ensure even cooling and prevent development of an insulating steam cushion over portions of the part. The harness can be tailored by the temperature of the initial heating. Rapid quenching produces a surface hardness of about 58-64RC at some sacrifice to the elasticity of the material. The strength of the ultraelastic Type 60 Nitinol heat treated to about 50-55 Rockwell C and a strength of about 140,00 - 155,000 psi and has an elastic strain capability of about 3% up to about 6%.

To retain the ultraelastic properties in a portion of the workpiece but high hardness in other portions such as the edge of a ice skate blade, the portion that need not be hardened can be clamped in a heat sink and the other portion, such as the ice-contacting edge, is heated to a hardening temperature of 900°C-950°C and then rapidly quenched in water or other coolant. The heat sink prevents the unhardened portion from being heated to the hardening temperature so it retains its ultraelastic properties.

Obviously, numerous modifications and variations of the preferred embodiment described above are possible and will become apparent to those skilled in the art in light of this specification. For example, the ice skating blade in accordance with this invention could be used for improved speed and control on sleds and ice boats, and on other sporting vehicles intended for use on ice, such a luge, bobsled and skeleton. Moreover, many functions and advantages are described for the preferred embodiment, but in many uses of the invention, not all of these functions and advantages would be needed. Therefore, I contemplate the use of the invention using fewer than the complete set of noted features, process steps, benefits, functions and advantages. For example, all the process elements may be used to produce a particular part that requires the characteristics provided by each process element, or alternatively, they may be used in

combinations that omit particular process elements or substitute others to give the desired characteristics of the part. Moreover, several species and embodiments of the invention are disclosed herein, but not all are specifically claimed, although all are covered by generic claims. Nevertheless, it is my intention that each and every one of these species and embodiments, and the equivalents thereof, be encompassed and protected within the scope of the following claims, and no dedication to the public is intended by virtue of the lack of claims specific to any individual species. Accordingly, it is expressly intended that all these embodiments, species, modifications and variations, and the equivalents thereof, in all their combinations, are to be considered within the spirit and scope of the invention as defined in the following claims, wherein I claim:

1. An ice skate blade, comprising:

an elongated blade body made from Type 60 Nitinol;

said blade body having an ice-contacting bottom edge, and a main blade portion;

said main blade portion having structure for engaging a blade holder;

said bottom edge having opposed corners that are sharpened to bite into ice for turning and accelerating;

said main blade portion having an impact strength of greater than 45 foot-pounds and a hardness of 45-55 RC.

2. An ice skate blade as defined in claim 1, wherein:

said main blade portion has a tensile strength of greater tan 130KSI and an elastic elongation of more than 3%.

3. An ice skate blade as defined in claim 1, wherein:

said bottom edge has a hardness exceeding 55RC.

4. An ice skate blade as defined in claim 1, further comprising:

an integral surface material on said bottom edge having a hardness exceeding 65RC and a low coefficient of friction on ice.

5. A method for producing a hollow grind on the running edge of a Type 60 Nitinol ice skate blade, comprising:

grinding said running edge to roughly a desired hollow profile using a silicon carbide blade;

grinding to a desired final hollow profile using a diamond hone; and

polishing said edge after said diamond hone grinding step using diamond paste on a buffing wheel.

6. A method of making ice skate blades, comprising:

selecting a Type 60 Nitinol sheet that has been hot-worked at a temperature of about 900°C to 950°C to a reduction of at least about 2% in the dimension of said hot-working;

cutting ice skate blade blanks from said sheet;

heating said blanks to between 600°C to about 800°C and immediately quenching said blanks to ambient temperature to produce blanks having a hardness of about 48-53RC;

grinding one edge of said blade blanks to a desired profile and sharpness;

heating said one edge to an elevated temperature of about 850-1000°C and immediately quenching said blade blank to produce a hardness at said one edge of above 56RC.

7. A method as defined in claim 6, further comprising:

heat treating of the bottom of the blade to produce a very hard and erosion resistant surface

Abstract of the Disclosure

A Nitinol skate blade includes a skate blade body having attachment structure by which it is held in a skate blade holder of an ice skate. The processes and products made by the processes. The processes include selecting a Type 60 Nitinol sheet that has been hot-worked at a temperature of about 900°C to 950°C to a reduction of at least about 2% in the dimension of said hot-working. Blade blanks are cut from the sheet, and the blade blanks are heated to between 600°C to about 800°C and immediately quenched to ambient temperature to produce blanks having a hardness of about 48-53RC. The running edge of the blade blanks are ground to a desired profile and sharpness. The ground blades may then be heated to an elevated temperature of about 850-1000°C and immediately quenched to produce a hardness at the edge of above 56RC.

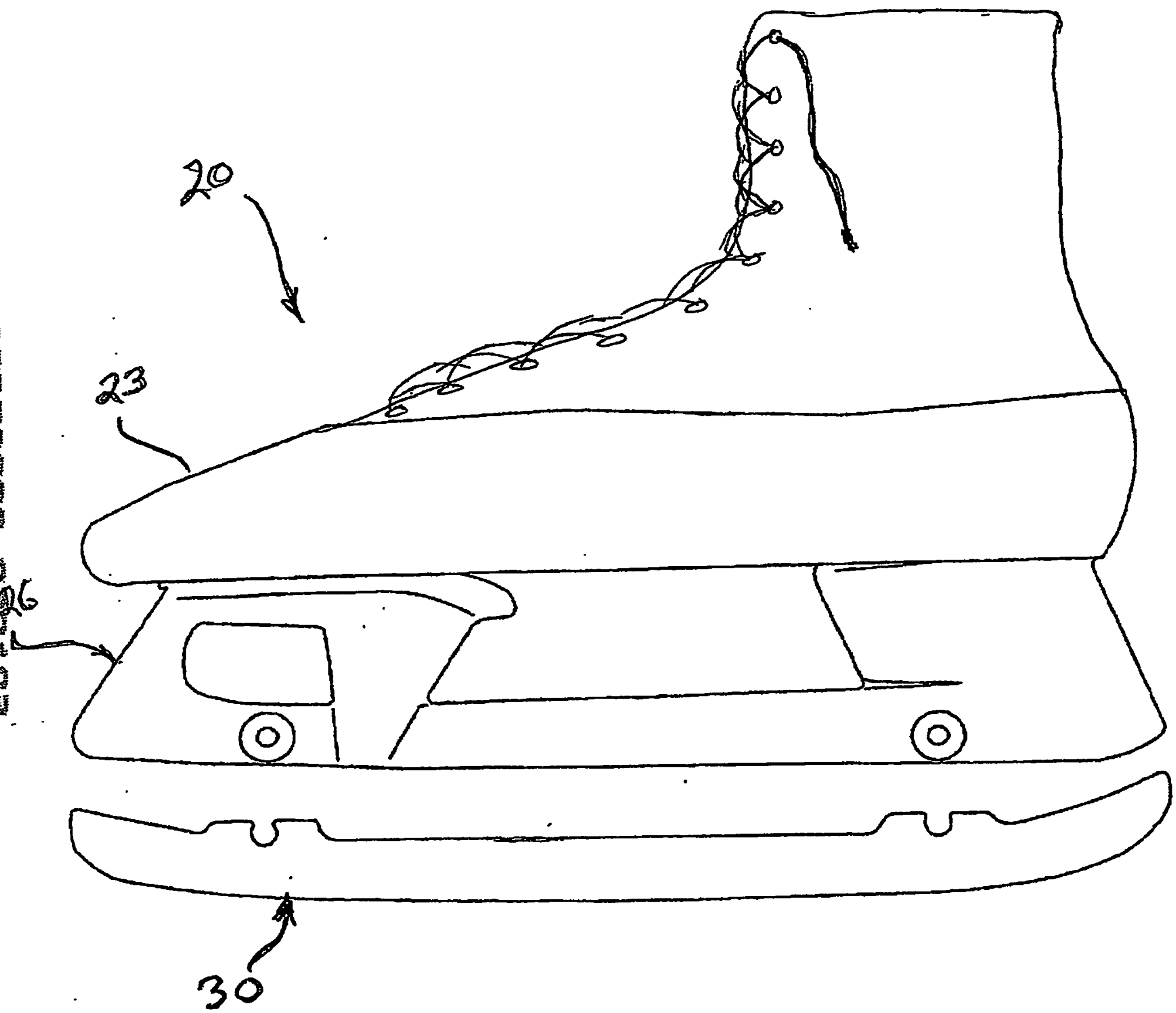

Fig. 1

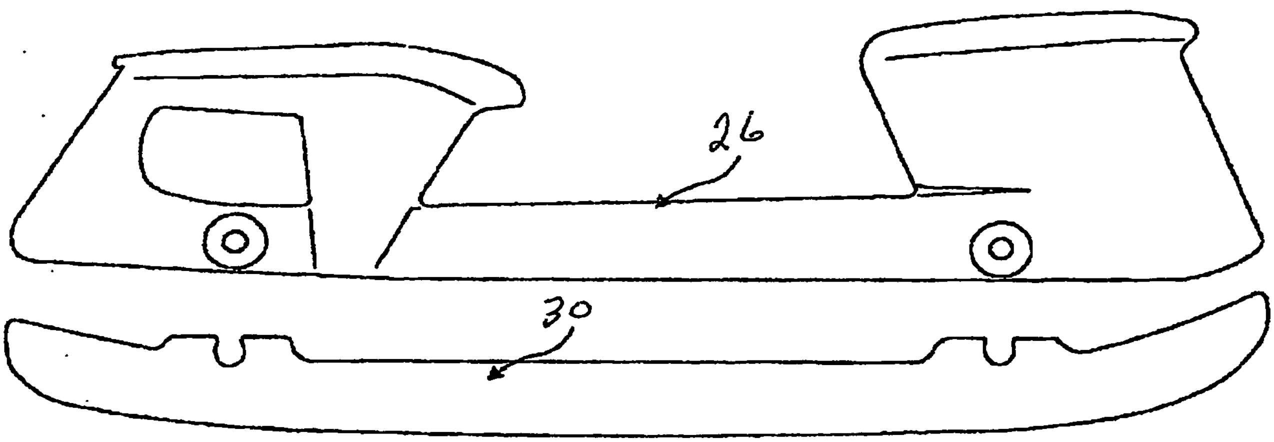

Fig. 2

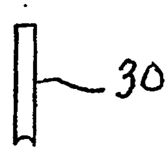

Fig. 3

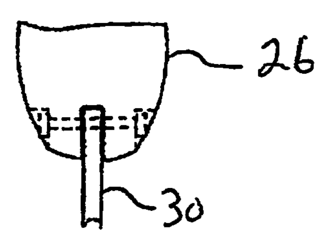

Fig. 4

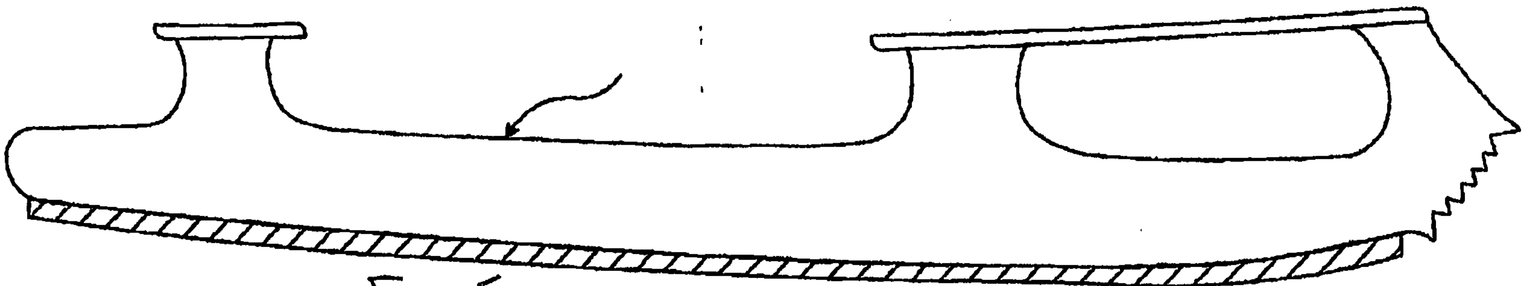

Fig. 5

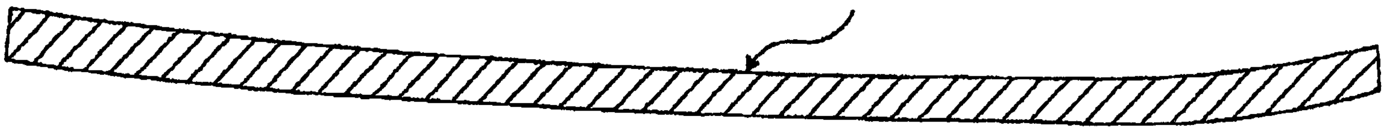

Fig. 6

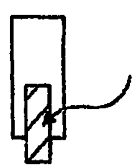

Fig. 7

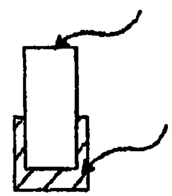

Fig. 8

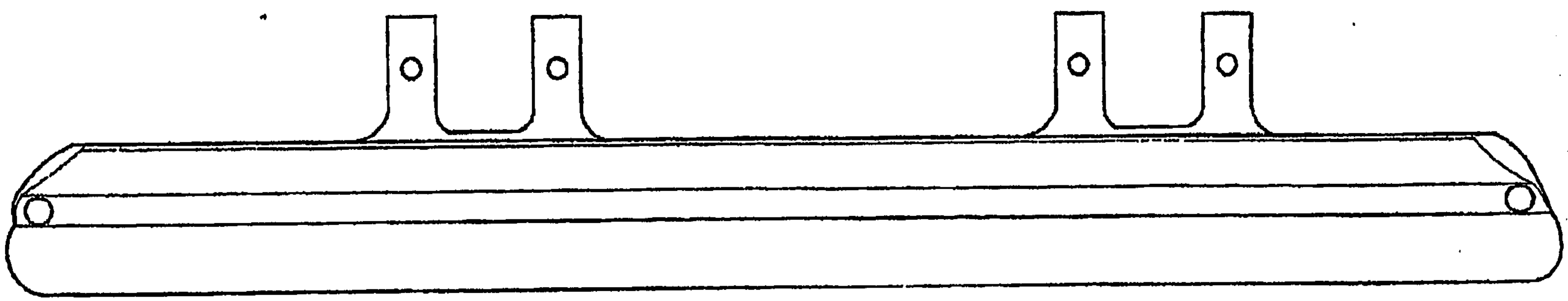

Fig.9

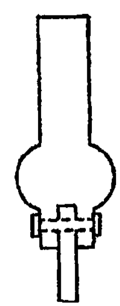

Fig.10